Puget Sound Nutrient Modeling

Nutrient pollution is considered one of the largest threats to Puget Sound. Recognized nation-wide, the following characteristics of nitrogen pollution apply equally and imperatively to Puget Sound (Howarth, 2006):

- Human acceleration of the nitrogen cycle over the past 40 years is far more rapid than almost any other aspect of global change.
- Nutrient pollution leads to hypoxia and anoxia, degradation of habitat quality, loss of biotic diversity, and increased harmful algal blooms.
- Technical solutions exist and should be implemented, but further scientific work can best target problems and solutions, leading to more cost effective solutions.

This proposal lays out a plan for the Washington State Department of Ecology (Ecology), working collaboratively with EPA, to conduct nitrogen pollution modeling in Puget Sound, to complement associated regulatory and management initiatives (see complementary AKART proposal). This work is being conducted as part of EPA's and Ecology's mandate under the Clean Water Act to manage pollutant loading to meet water quality standards.

Project Objective

Use Puget-Sound-wide hydrodynamic models at three scales to answer the following nutrient management questions:

- Are current nitrogen loadings from point and nonpoint sources in and around Puget Sound significantly impacting water quality at a large scale?
- What nutrient reductions are necessary to reduce or eliminate human impacts to biomass and dissolved oxygen levels in sensitive embayments?

Project Description

This project consists of four parts:

I. Establish a set of multi-purpose hydrodynamic models for the entire Puget Sound at three scales, large, intermediate, and fine. This work will be done by contractual agreement, building on work already completed. These models can also serve as community tools for other purposes.

II. The large-scale model (also called "box model") will be used by Ecology to do a screening-level evaluation of nutrient effects on dissolved oxygen, Puget-Sound-wide. The results of this effort will inform the more detailed work below.

III. The intermediate-scale model (also called "coarse grid model") will be used by Ecology to evaluate the effect of human-caused nutrient enrichment on dissolved oxygen across Puget Sound. This model will help inform potential Puget-Sound-wide management strategies and decisions. It will also inform the more detailed work below.

IV. The fine-scale model (also called "high-resolution grid model") will be used for site-specific studies, including Total Maximum Daily Load or related studies in critical areas with known dissolved oxygen problems. This model can also be used to evaluate potential causes of nuisance algae, such as excess sea lettuce accumulating on beaches, by differentiating the local (tributary) vs greater Puget Sound contributions of nutrients.

A technical advisory committee comprised of stakeholders will be used to help advise this work.

The chart below shows the three scales of models and the water quality information to be used for nutrient modeling at each scale.

Hydrodynamics (3-D water circulation)		Application	Types of Watershed Data Sources for Nutrient Modeling	Types of Point Source Data Sources for Nutrient Modeling
Box Model	→	Screening-Level Analysis of Nutrient Dynamics	Existing USGS and Ecology information	Extrapolated South Puget Sound data
Coarse Grid	→	Estimation of Point and Non-point Source Impacts on Puget Sound DO	Existing information and empirical/statistical approaches	Expanded voluntary South Puget Sound monitoring to all Puget Sound
High-resolution Grid	→	Detailed Analysis of Sensitive Embayments	Site-specific embayment data collection and rainfall/runoff models	Site-specific data collection

Project Tasks

I. Develop set of Models

Develop a set of hydrodynamic models at three scales for the entire Puget Sound, building on work already completed. Steps include: model selection (based on pre-set criteria), development, and corroboration of results with available data and other models for smaller geographic areas, such as the South Puget Sound model. Ecology will coordinate with PSMEM-C members on model selection criteria and selection. Ecology would like this set of models to serve as community tools that can be used for other applications such as Toxics, Bacteria, Nearshore Restoration, and Spill Tracking, to the extent possible.

II. Box Nutrient Model (Large Scale)

1. Use the large-scale hydrodynamic box model as a base for a water quality model that simulates the impact of nutrients on phytoplankton and dissolved oxygen.
2. Using existing information on tributary and point-source loading of nutrients to Puget Sound, develop the water quality model to make preliminary findings on the effect of dissolved oxygen across the sound. Results will show critical areas and times and provide boundary conditions, initial conditions, and parameter estimates for the next level of analysis (below).

III. Coarse Grid Puget-Sound-Wide Nutrient Model

1. Use the intermediate-scale hydrodynamic model as a base for a water quality model that simulates the effects of nutrients on phytoplankton and dissolved oxygen.
2. Develop estimates of current watershed nutrient loading to Puget Sound based on existing data and statistical/empirical approaches.
3. Develop estimates of current direct point-source nutrient loading based on extrapolating results from the South Puget Sound study.
4. Develop the water quality model for making management decisions. Also provides boundary conditions, initial conditions, and parameter estimates for detailed basin-specific studies (below).

IV. Detailed Nutrient Studies

1. Develop a water quality model to work together with the high-resolution grid hydrodynamic model. Corroborate by comparing to available data and models at smaller scales.
2. Continue developing basin-specific TMDL studies. Current focus is on South Puget Sound; next area of focus is likely Whidbey Basin. This proposal includes writing a Quality Assurance Project Plan for the next basin-specific TMDL.

Outcomes

- Set of Puget Sound-wide models at three scales for multiple uses and improved Puget Sound modeling coordination.
- Quantitative information on dissolved oxygen impairments due to excess nutrients to support Ecology's nutrient management decisions at both a regional and site-specific scale.
- A basis for subsequent model-based analyses using these tools to assess effects from different pollutants.

Budget

I. Set of Community Hydrodynamic Models and Web Site	
• Definition of Model Selection Criteria, Project and Contract Management, Evaluation of Model Performance	$ 50,000
• Model Development and Support (Contract)	$220,000
II. Box Model (Large Scale)	
• Box Model Refinement	$ 30,000
• Data Compilation, Analysis, and Report	$ 50,000
III. Coarse Model	
• Water Quality Model Refinement (contract)	$ 70,000
• Data Compilation, Analysis, and Report	$130,000
• Equipment ~~(Unix computer cluster @ $35k + one Windows-based modeling computer @$15k)~~	$ 50,000
IV. Fine-Scale Model	
• Confirm fine-scale water quality model by comparing output to South Puget Sound results	$ 50,000
• QAPP for the next TMDL Study (possibly Whidbey Basin	$ 40,000
Total	$690,000

[Add in $$ for a WQP Communications/Coordination Lead?]

Schedule

Parts I- III: July 1, 2008 – June 30, 2009
Part IV: July 1, 2009 – June 30, 2010

Applicant Contact

Rob Duff
Washington State Department of Ecology
Environmental Assessment Program
Phone: (360) 407-6699 Fax: (360) 407-6884
Email: rduf461@ecy.wa.gov

Reference

Howarth, R., 2006. From presentation to the White House Office of Science and Technology Policy by Robert W. Howarth, *David R. Atkinson* Professor of Ecology & Environmental Biology, Cornell University, November 3, 2006.